

Direct air capture (DAC) of CO₂ using building HVAC System

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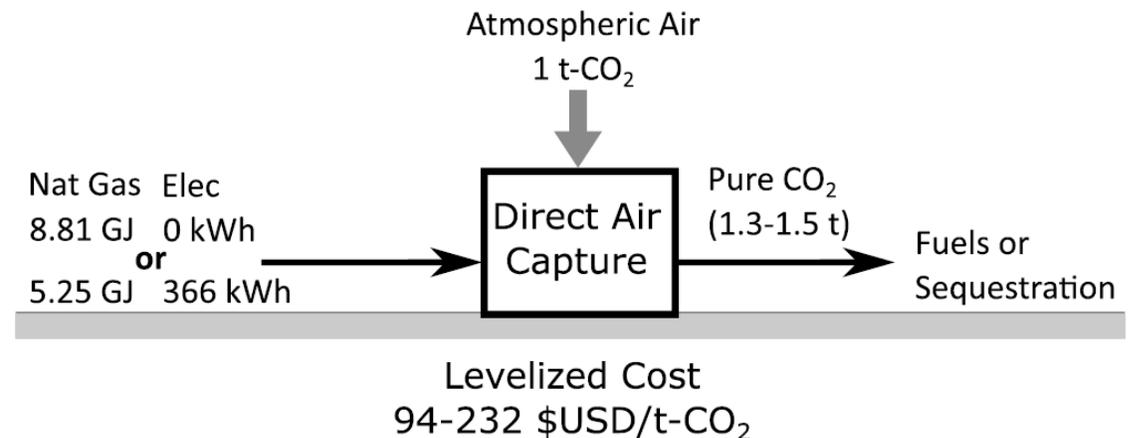
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Motivation

- Direct Air Capture (DAC) is a critical framework for decarbonizing the energy sector
- Higher capital and operational costs are major barriers for the implementation
- An extensive amount of energy associated with the regeneration process

How do we **overcome barriers** associated with higher cost and extensive regeneration energy?



Motivation

- There are over 120M buildings (residential ~114M, commercial ~6M)
- Existing building equipment moves large amounts of air (blowers and fans)
- Large amount of low-grade heat provide an opportunity for onsite utilization



A multifunctional approach combining DAC to air conditioning/thermal management can provide a potential solution: Distributed Direct Air Capture (DAC)



Technical approach

- Highly modular and scalable technology
- Distributed deployment with minimal cost (capital and operation)
- Deployment issues (integration, control, etc.)
- Compatible materials development



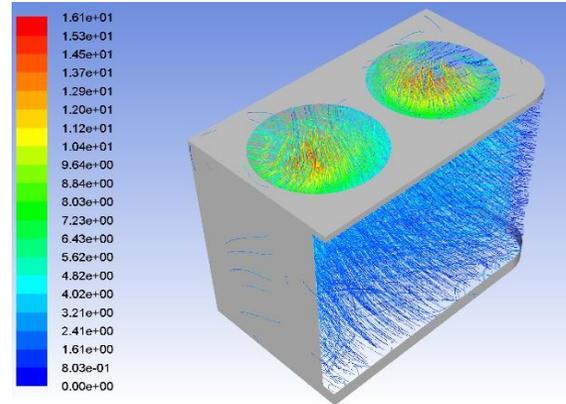
Deployment 1

DAC integrated in rooftop packaged unit

- Experimentation for performance evaluation over an extended period
- Data analysis to evaluate the impact of weather condition
- Evaluation of impact on the primary operation of system



12.5-ton capacity packaged rooftop units for retrofitting with DAC

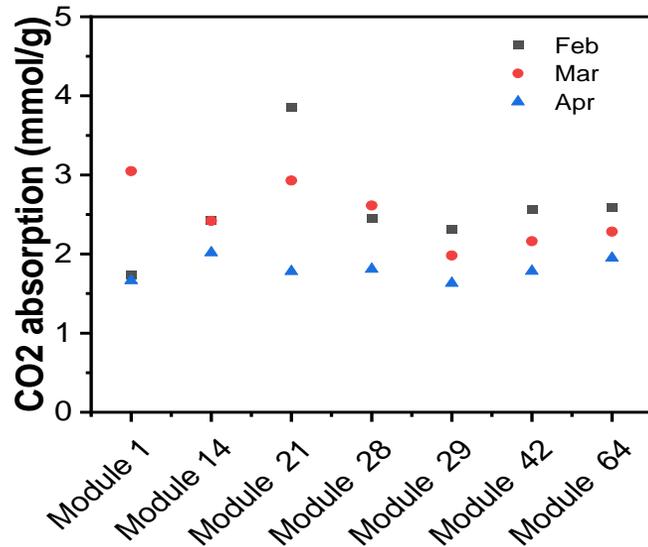


Velocity profile leads to non-uniform flow rate



Demonstration of ambient DAC

Experimental data for extended tests



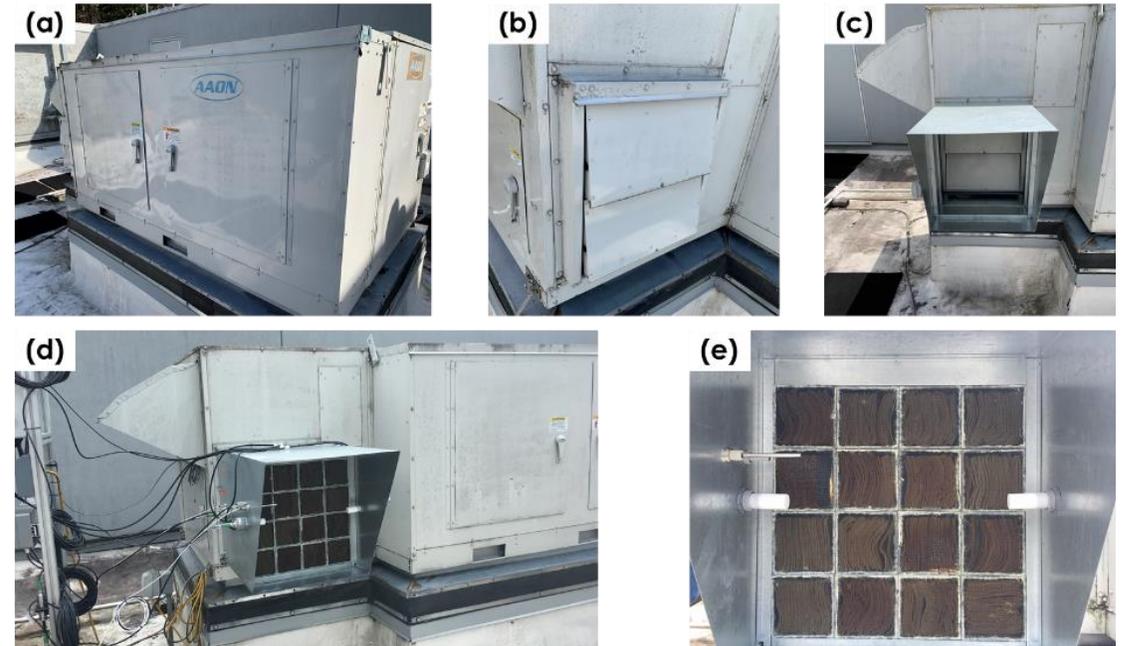
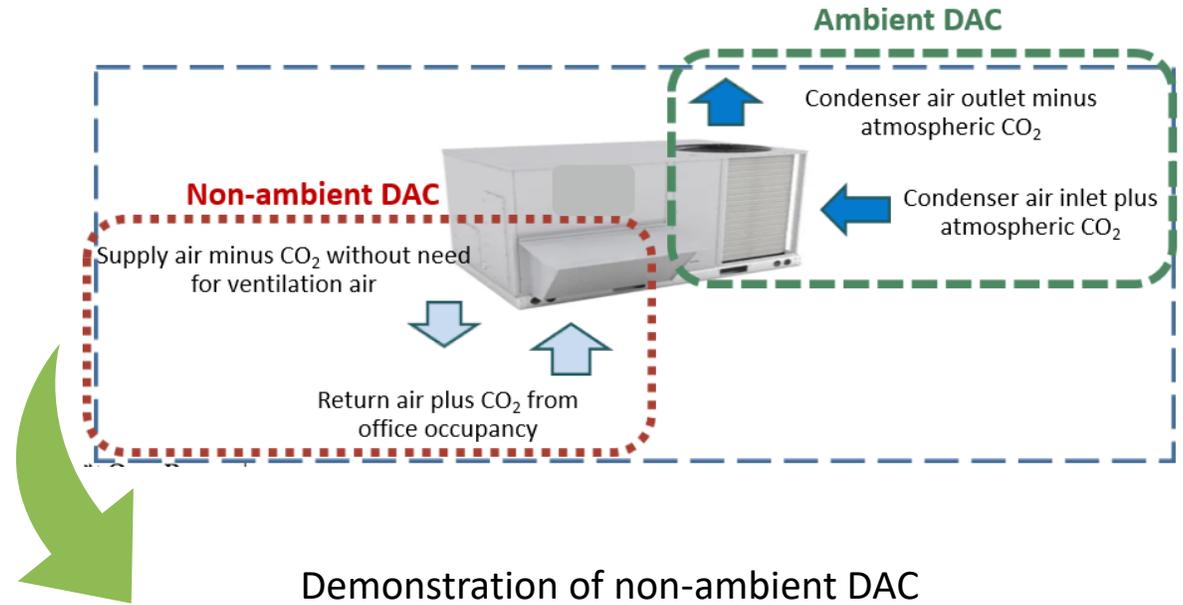
US patent 63/272,351, "Multi-functional Equipment for Direct Decarbonization with Improved Indoor Air Quality"

Deployment 2 DAC

Integrated to make-up air unit

- Return air from building has a higher CO₂ concentration (800-2,000 ppm)
- Experiments are in progress for the past 5 months
- Potential implications for tight envelopers (reduced ventilation)

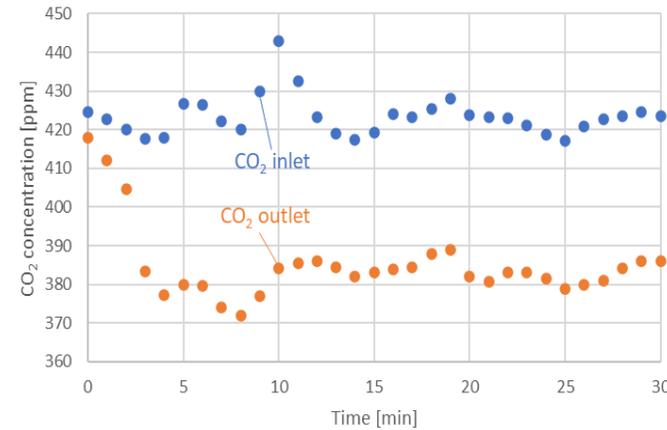
DAC can lead to improved indoor air quality in buildings (schools, restaurants)



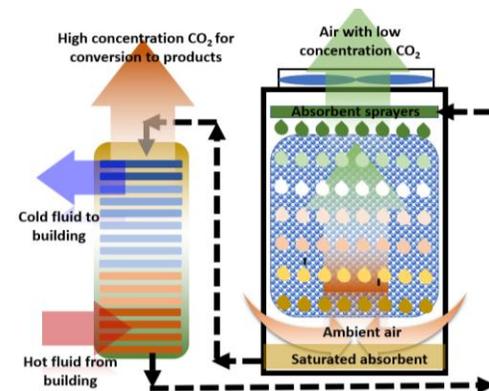
Deployment 3

Cooling towers retrofitted with DAC

- Cooling towers (direct and indirect evaporative cooling) are important for thermal management
- More than 250,000 installations for large-capacity cooling towers (Baltimore Aircoil Company)
- Simultaneous leverage of fluids movement and waste heat for regeneration



Preliminary experimental data



System integration (multi-functional platform)

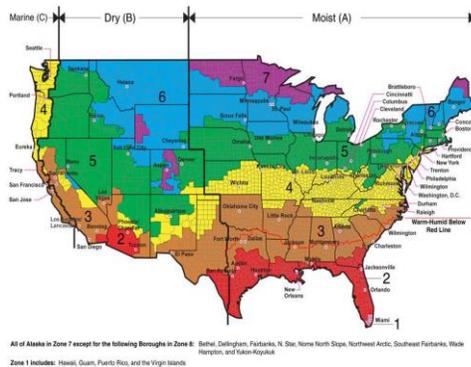


Cooling towers have been used for thermal management

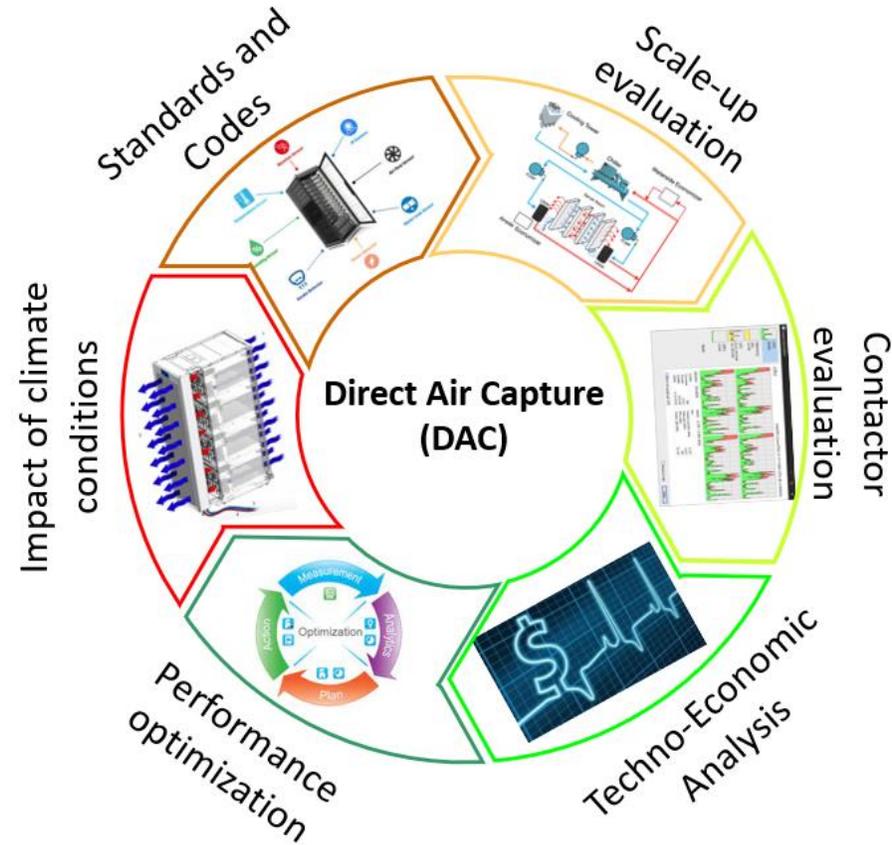
Development of Capabilities and Facilities



DAC in various climate zones



National climate data



Materials characterization



Contactor performance evaluation

Initial developments have resulted in one-of-their-kind facilities. ORNL can test any DAC technology at-scale under any climate condition

Concluding Remarks

- Retrofitting is a first step for realization of DAC integrated to HVAC system.
- Further modifications can lead to highly efficient solutions.
- Development of compatible materials and system configurations are critical.
- Any sustainable solution requires energy efficient regeneration strategy.
- CO₂ storage or transmission and utilization are obvious challenges.

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